

In the Specification:

Please amend the specification by substituting the paragraphs indicated below for the paragraphs as previously presented. Amendments to the specification are shown with additions underlined and deletions in [brackets].

Please replace the paragraph beginning at page 1, line 5 with the following paragraph:

[BY INVENTORS

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CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. Patent Application No. 09/748,051, filed on December 22, 2000, on behalf of Louis B. Rosenberg et al., entitled, "Computer Interface Apparatus Including Linkage Having Flex," which is a continuation of U.S. Patent Application No. 09/140,717, filed on August 26, 1998, now U.S. Patent No. 6,201,533, on behalf of Louis B. Rosenberg et al., entitled "Method and Apparatus For Applying Force in Force Feedback Devices Using Friction," which is a divisional of U.S. Patent Application No. 08/560,091, now U.S. Patent No. 5,805,140, on behalf of Louis B. Rosenberg et al., entitled "High Bandwidth Force Feedback Interface Using Voice Coils and Flexures," which is a continuation-in-part of U.S. Patent Application No. 08/374,288 filed on January 18, 1995, now U.S. Patent No. 5,731,804, on behalf of Louis B. Rosenberg et al., entitled "Method and Apparatus for Providing High Bandwidth, Low Noise Mechanical I/O for Computer Systems," which is a continuation-in-part of [co-pending parent patent application] U.S. Patent Application No. 08/461,170, originally filed July [16]5, [1993]1995, now U.S. Patent No. 5,576,727, on behalf of Louis B. Rosenberg et al., entitled, "Three-Dimensional Mechanical Mouse[,]". [and co-pending parent patent application 08/374,288, filed January 18, 1995 on behalf of Louis B. Rosenberg, entitled, "Method and Apparatus for Providing High Bandwidth, Low Noise Mechanical I/O for Computer Systems," both] Each of which is assigned to the assignee of this [present] application, and [both] each of which are hereby incorporated by reference herein.

Please replace the paragraph beginning on page 21, line 21 with the following paragraph:

Optionally, additional transducers can be added to apparatus 25' to provide additional degrees of freedom for object 44. For example, a transducer can be added to grip 26 of laparoscopic tool 18 to sense when the user moves the two portions 26a and 26b relative to each other to simulate extending the cutting blade of the tool. Such a laparoscopic tool sensor is described in U.S. Patent [Application Serial No. 08/275,120] No. 5,623,582, filed July 14, 1994 and entitled "Method and Apparatus for Providing Mechanical I/O for Computer Systems" assigned to the assignee of the present invention and incorporated herein by reference in its entirety.

Please replace the paragraph beginning on page 25, line 3 with the following paragraph:

Other drive mechanisms can also be used to transmit forces to linear axis member and receive positional information from member 40 along axis C. For example, a drive wheel made of a rubber-like material or other frictional material can be positioned on shaft 98 to contact linear axis member 40 along the edge of the wheel. The wheel can cause forces along member 40 from the friction between wheel and linear axis member. Such a drive wheel mechanism is disclosed in the abovementioned [Application Serial No. 08/275,120] Patent No. 5,623,582 as well as in U.S. Patent [Application Serial No. 08/344,148] No. 5,821,920, filed November 23, 1994 and entitled "Method and Apparatus for Providing Mechanical I/O for Computer Systems Interfaced with Elongated Flexible Objects" assigned to the assignee of the present invention and incorporated herein by reference in its entirety. Linear axis member 40 can also be a single shaft in alternate embodiments instead of a dual part sleeve and shaft.

Please replace the paragraph beginning on page 28, line 15 with the following paragraph:

Digital sensors 128 provide signals to computer 16 relating the position of the user object 44 in 3D space. In the preferred embodiments described above, sensors 128 are relative optical encoders, which are electro-optical devices that respond to a shaft's rotation by producing two phase-related signals. In the described embodiment, sensor interface circuit 130, which is preferably a single chip, receives the signals from digital sensors 128 and converts the two

signals from each sensor into another pair of clock signals, which drive a bi-directional binary counter. The output of the binary counter is received by computer 16 as a binary number representing the angular position of the encoded shaft. Such circuits, or equivalent circuits, are well known to those skilled in the art; for example, the Quadrature Chip LS7166 from Hewlett Packard, California performs the functions described above. Each sensor 28 can be provided with its own sensor interface, or one sensor interface may handle data from multiple sensors. For example, the electronic interface described in [parent] patent [Application Serial No. 08/092,974] No. 5,576,727 describes a sensor interface including a separate processing chip dedicated to each sensor that provides input data.

Please replace the paragraph beginning on page 51, line 11 with the following paragraph:

For example, in one embodiment, host computer 16 can provide low-level force commands over bus 404, which microprocessor 410 directly provides to actuators 126. In a different embodiment, host computer 16 can provide high level supervisory commands to microprocessor 410 over bus 404, and microprocessor 410 manages low level force control ("reflex") loops to sensors 128 and actuators 126 in accordance with the high level commands. Host computer 16 can send host commands to the microprocessor to select a type of force for the microprocessor to independently implement in a reflex loop. Microprocessor 410 can continually read data from sensors 128 for the position and motion of object 44 and compute forces on the object according to the sensor data, timing data from clock 413, and/or subroutines or reflex processes selected in accordance with the host commands. The processor then outputs a processor command to an actuator to apply the computed force. Such a process is described in greater detail in [co-pending] patent [application serial no. 08/534,791] No. 5,739,811, assigned to the same assignee as the present application and incorporated by reference herein.

Please replace the paragraph beginning on page 52, line 19 with the following paragraph:

Other types of interface circuitry 36 can also be used. For example, an electronic interface is described in abovementioned [parent] patent [application Serial No. 08/092,974] No. 5,576,727. The electronic interface described therein has six channels corresponding to the six degrees of freedom of a stylus. The interface allows the position of the mouse or stylus to be tracked and provides force feedback to the mouse using sensors and actuators. Sensor interface

130 can include angle determining chips to pre-process angle signals reads from sensors 128 before sending them to the microprocessor 410. For example, a data bus plus chip-enable lines allow any of the angle determining chips to communicate with the microprocessor. A configuration without angle-determining chips is most applicable in an embodiment having absolute sensors, which have output signals directly indicating the angles without any further processing, thereby requiring less computation for the microprocessor 410 and thus little if any pre-processing. If the sensors 128 are relative sensors, which indicate only the change in an angle and which require further processing for complete determination of the angle, then angle-determining chips are more appropriate.